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Abstract:
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Index Terms:
UHF filters digital radio fading microwave links spread spectrum communication surface acoustic wave filters telecommunication channels wireless LAN 2 Mbit/s 2.45 GHz 22 dB 348.5 MHz 80 MHz ISM band SAW based chirp spread spectrum system WLAN channel characteristics data throughput narrowband fading wireless LAN system

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DESIGN AND VERIFICATION OF A SAW BASED CHIRP SPREAD SPECTRUM SYSTEM

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ABSTRACT

We report on the design and performance of a SAW based spread spectrum wireless LAN system which operates in the ISM band at 2.45 GHz. System IF frequency, transmission bandwidth and data rate are 348.8 MHz, 80 MHz, and 2 Mbit/s, respectively. Due to the high processing gain of 22 dB - made possible by the use of SAW devices - and the large transmission bandwidth the system is insensitive against narrowband fading and noise.

We give a brief system overview and present measurements of the data throughput. Comparison with simulation results focused primarily on measured and modeled channel characteristics will also be presented.

INTRODUCTION

The interest in indoor wireless communications has grown rapidly in recent years due to advantages over cable networks, such as mobility of users, elimination of cabling, flexibility, and creation of various new communication services. In indoor radio communication special propagation problems arise due to the highly reflective and shadowing environment. In the indoor channel, which depends heavily on the type of building, radio signals propagate via multiple paths which differ in amplitude, phase and delay time. This leads to time distortion and narrowband fading. Further problems of indoor environment are the electromagnetic emission of home appliances and other wireless communication systems. Systems based on the spread spectrum technique are able to overcome these problems. Chirp signals and the associated technique of pulse compression with its high processing gain as extensively used in radar systems [1] are well suited for spread spectrum transmission. The use of small size and low cost Surface Acoustic Wave (SAW) devices for both - chirp generation and pulse compression - makes this technique even more favorable [2].

SYSTEM OVERVIEW

For a linear chirp waveform the instantaneous frequency varies linearly with time. If we take the waveform to be centered at $t = 0$ it can be written as

$$s(t) = a(t)\cos\left(2\pi f_c t + \pi\mu t^2 + \varphi_0\right) . \quad (1)$$

where $a(t), f_c, \varphi_0$, and μ are the envelope, the center frequency, the phase constant, and the chirp rate, respectively. The latter indicates the rate of change of instantaneous frequency. Waveforms with $\mu > 0$ are called up-chirps while those with $\mu < 0$ are called down-chirps. In our case the instantaneous frequency varies from 308.8 MHz to 388.8 MHz within the chirp duration of 2 μs. If a chirp waveform is fed into its matched filter, whose impulse response is also a chirp waveform but with its frequency varying in the opposite direction, then the output signal typically has a narrow RF peak at the chirp center frequency. Additionally interfering time sidelobes appear on either side. We use square root Hamming weighted

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chirps which leads to a sidelobe rejection of about 42 dB as is shown in Fig.1.

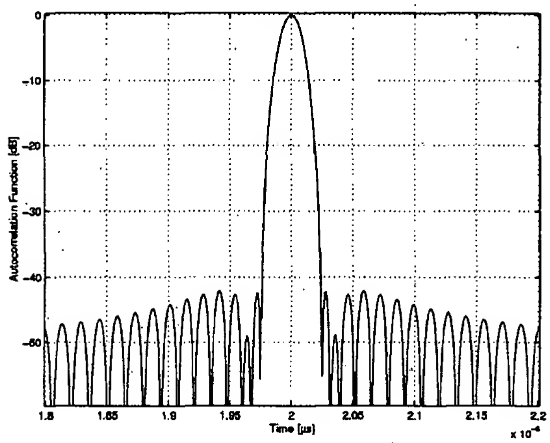

Figure 1: Envelope of the autocorrelation function of a square root Hamming weighted chirp waveform.

The width of the correlation peak is about 50 ns and hence much shorter than the transmitted chirp signal.

Fig.2 shows the schematic of a SAW based wireless LAN using binary orthogonal keying (BOK). The applied data rate of the presented system is 2 Mbit/s. If we send a 'high', an IF pulse at the chirp center frequency of 348.8 MHz stimulates the up-chirp filter, if we send a 'low', the down-chirp filter is stimulated. From the data rate of 2 Mbit/s it follows that the chirp signals overlap in time after the summation. The sum of both filter outputs is launched at a transmitter frequency of 2.45 GHz. In the receiver the signal, which is disturbed by the frequency selective radio channel and additive noise, is mixed down and fed into the SAW compressor filters. The up-chirp filter is matched to the 'low' signal, the down-chirp filter to the 'high' signal. In both paths non-coherent envelope detection with hard decision and an adaptive threshold control follows. The effect of overlapping and the fact that up- and down-chirps are not exactly orthogonal leads to disturbing crosscorrelation functions in both filter outputs. Together with the time spreading of the correlation peaks caused by the multipath channel this limits the achievable data rate.

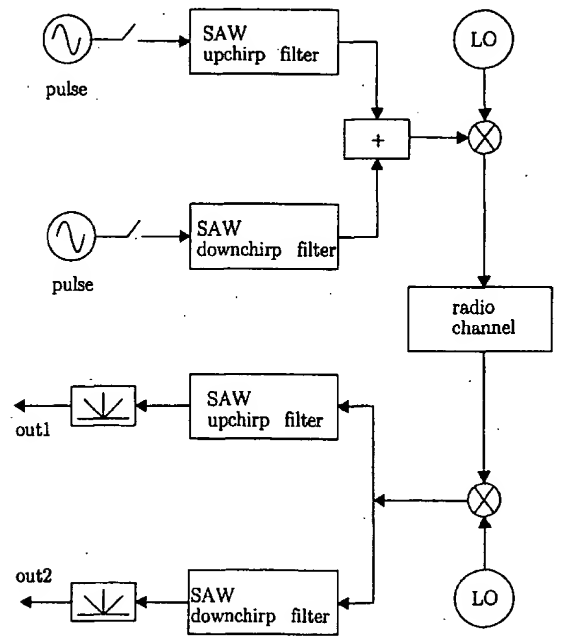

Figure 2: Schematic of a SAW BOK wireless LAN.

CHANNEL MEASUREMENTS- AND SIMULATIONS

To improve the performance of a communication system in a timely, cost effective and effort free manner it is useful to use computer aided analysis. To simulate broadband WLAN systems it is necessary to emulate the radio channel characteristics in the form of mathematical models. For that reason wideband measurements [3, 4] of indoor radio channels at 2.45 GHz have been conducted for LOS and NLOS cases in a laboratory/office environment in the fourth floor of a six story building. From the measured impulse response profiles, mean delay spread, coherence bandwidth, and path loss exponents have been estimated. Comparison with simulation re-

sults extracted from the SIRCIM simulator package [5] has also been made. Fig.3 compares measured and simulated impulse response profiles for a transmitter receiver distance of 5 m and LOS topography.

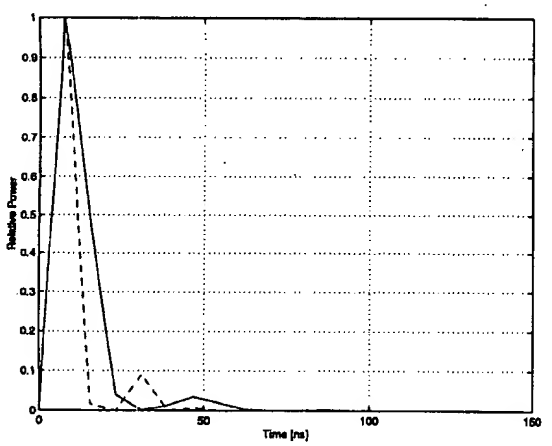

Figure 3: Comparison between measured and simulated indoor channel impulse responses for a transmitter receiver separation of 5 m and LOS topography.

Measurements and simulations indicate that the mean delay spread is significant larger in NLOS topographies. For different environments values from 10 ns to 50 ns have been computed. Values for the coherence bandwidth have been estimated in the range of 5 MHz to 20 MHz. For LOS cases measurements and simulations give path loss exponents between 2.0 and 2.3, while for NLOS cases values in the range of 2.7 to 3.1 have been computed. Summarizing we can say that measured and simulated data coincide well so that the SIRCIM simulator can be used as a basis for realistic simulations of indoor wireless systems.

SYSTEM MEASUREMENTS- AND SIMULATIONS

System measurements have been done with an experimental setup in the same environment as described above. Fig.4 shows the measured output signal of the down-chirp matched filter and the corresponding output of the envelope detector for a transmitter receiver distance of 5 m and LOS topography for the case that a sequence of 'high' bits is sent.

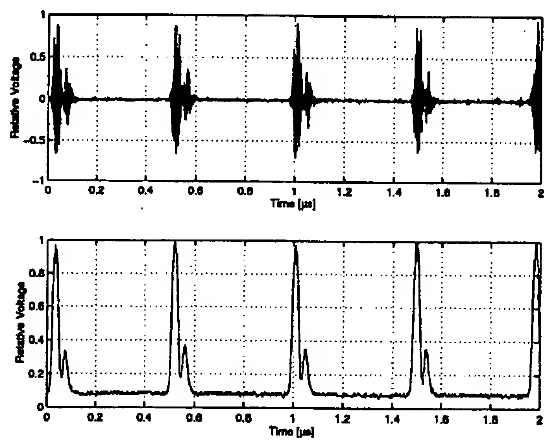

Figure 4: Measured matched filter (top) and envelope detector (bottom) outputs for a 'high' bit data sequence.

A small echo peak after the strong direct path appears. No interfering crosscorrelation functions occur since no overlapping 'low' signals are present in the regarded time window. Fig.5 compares measured (top) and simulated (bottom) outputs of one envelope detector for similar environment conditions when 'high' and 'low' bits are sent alternately. The appearance of disturbing crosscorrelation functions can be observed in that case. In simulations with worse environmental conditions the spreading effect of the frequency selective radio channel was observed in addition to the crosscorrelation disturbances. From the presented results it can be gathered that these effects mainly limit the achievable data rate. Measurements showed that the system overcomes the influence of narrowband fading due to the transmission of broadband signals. Bit errors occur in clusters mainly caused by large scale fading due

to shadowing effects.

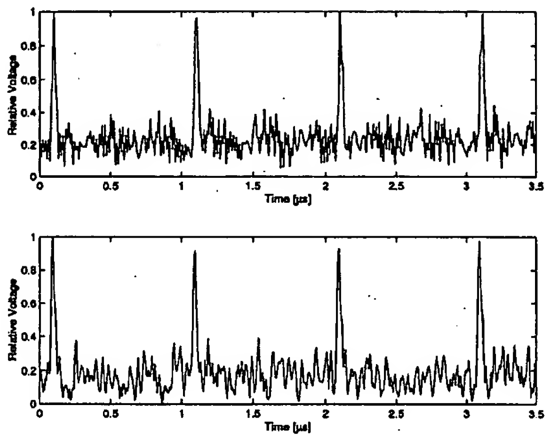

Figure 5: Comparison between measured (top) and simulated (bottom) output signals.

CONCLUSION

The present work demonstrates a chirp spread spectrum system for wireless data transmission in indoor environments. SAW technololgy is used for chirp generation in the transmitter and for pulse compression in the receiver. The achievable data rate is limited by the spreading effect of multipath fading and by disturbances of crosscorrelation functions which occur because of systematic time-overlapping of successive symbols. Further investigations will concentrate on high order chirp modulation principles and more complex detection schemes to increase the achievable data rate by reducing the disturbing influences described above.

References

[1] D. P. Morgan, *Surface Wave Devices for Signal Processing*, Elsevier, Amsterdam, 1985.

[2] A. Springer, A. Pohl, W. Gugler, M. Huemer, L. Reindl, F. Seifert, R. Weigel, "A Robust Ultra Broadband Wireless Communication System Using SAW chirped Delay Lines", to be presented at the IEEE MTT-S International Microwave Symposium, 1998.

[3] M. Huemer, A. Pohl, W. Gugler, A. Springer, "Messung und Simulation von Indoor Kanälen bei 2.45 GHz, *Proceedings ITG-Fokusprojekt Mobilkommunikation - Systeme mit intelligenten Antennen*, Kaiserslautern, Germany, 1997 (in German).

[4] N. Papadakis, A. Hatziefremidis, A. Tserolas, P. Constantinou, "Wideband Propagation Measurements and Modeling in Indoor Environment", *International Journal of Wireless Information Networks*, vol. 4, no. 2, pp. 101-111, 1997.

[5] T.S. Rappaport, S.Y. Seidel and K. Takamizawa, "Statistical Channel Impulse Response Models for Factory and Open Plan Building Radio Communication System Design", *IEEE Transactions on Communications*, vol. 39, pp. 794-807, May 1991.